Structural BMPs are generally the costliest of the various BMPs to implement and to maintain. Most potential BMP owners are generally aware of the initial construction costs and land allocation that is required for structural BMPs, but some do not fully understand or appreciate the responsibility and costs associated with the maintenance of stormwater BMPs. This manual presents design, installation, and maintenance guidelines for each structural BMP.

This manual describes each structural BMP and provides design guidelines to make the BMP as efficient as possible in removing pollutants. The manual points out which BMPs are acceptable to use to meet water supply watershed protection regulations for high density development and the associated minimum design requirements. The manual describes each BMP's ability to incorporate peak flow reduction and their credit potential toward the stormwater utility fee. The manual also provides guidelines on selecting the best BMP for certain site conditions.

The following structural BMPs are discussed in Sections 3.4, 3.5, and 3.6 of this manual. Section 3.4 presents BMP selection guidelines, regulatory considerations and design information for each structural BMP. Section 3.5 provides general installation guidelines, while Section 3.6 provides inspection and maintenance guidelines for each structural BMP.

- ⇨ Grass swales
- ⇨ Filter strips
- ⇨ Dry detention basins
- ⇨ Wet detention ponds
- ⇨ Stormwater wetlands
- ⇨ Bioretention areas
- ⇨ Sand filtration facilities
- ⇨ Proprietary stormwater treatment facilities

3.2 Pollution Prevention BMPs

3.2.1 Employee Education

Description

Employee education programs are designed to educate employees on the proper operational practices to minimize the potential for on-site pollutants to contact stormwater runoff. Through education, employees become more aware of potential stormwater pollutants, runoff characteristics, spill control measures, and methods to minimize off-site migration of polluted stormwater runoff from commercial and industrial properties. As a result, it is one of the easiest to implement and most beneficial pollution prevention BMPs available. In addition, a proper employee education program outlines methods by which employees can also reduce potential for stormwater pollution at their individual residences.

Applicability

Every commercial, and industrial or related facility that stores materials outside or is involved with receiving or shipping materials can benefit from employee education programs regarding on-site stormwater management practices.

Employee education programs are required by federal law under *40 CFR Part 112 - Oil Pollution Prevention Regulations* and *40 CFR Part 122, 123, and 124 - National Pollutant Discharge Elimination System Regulations for Storm Water Dischargers*. As a result, all facilities conforming to these regulations should already be performing employee education.

Stormwater Utility Credit

To be eligible for stormwater utility credit for implementation of this BMP, organizations must meet the minimum criteria outlined in Table 3.1. For more information regarding credit opportunities, refer to the City's *Stormwater Utility Credit Policy* document.

City of Greensboro Public Education Outreach

The City of Greensboro is committed to educate citizens on environmental awareness issues. The Storm Water Services Division, as part of its municipal NPDES permit, has developed educational programs to inform citizens on ways they can help protect the quality of Greensboro's streams and lakes. The City has produced several television and radio ads.

Table 3.1: Summary of Employee Education Requirements

ACTIVITY	DESCRIPTION	FREQUENCY	DOCUMENTATION
Employee Briefings	Education sessions for all employees regarding proper water quality and environmental protection activities.	30 min./quarter	Submit programs with agenda to SWS for approval prior to briefings.
Employee Surveys	Conduct written surveys of each employee per EPA regulations	Once annually	Submit summary of survey responses in Annual Report.
Post/Distribute Information	Post and/or distribute periodic stormwater information provided by Storm Water Services.	As received	Verify posting of Annual Report.

campaigning surface water quality protection. The City has also produced informational videos, brochures, etc., on various environmental topics for a wide range of audiences, including industries, businesses, schools and interested citizens.

The City also has helped form several volunteer groups to help educate citizens on water quality issues and to encourage citizens to get involved in cleaning up the City's surface waters. These groups include:

Environmental Business Partners
This program is setup to create a partnership with the City government and local businesses in order to provide the community with environmental/stormwater information.

"Green Heroes" (Includes Adopt-A-Stream, Adopt-A-Street, and Adopt-A-Park)
This program consists of volunteer groups that periodically remove litter along the stream section that they have adopted.

"Drain Markers" Program
This program involves placing the drain markers on storm water inlets that read "Don't Dump – Drains to Lakes and Creeks"

The City has also set up an "Environmental Helpline" (373-2812) to take calls on pollution problems from spills to excessive erosion problems from construction sites and to answer questions.

If you have an interest in obtaining any informational material, participating in the volunteer groups or have any other questions regarding environmental issues, please contact the Helpline.

3.2.2 On-Site Refuse Management

Description

On-site refuse management programs include specific operating practices designed to minimize the potential for on-site litter and debris. The goal for these types of programs is to limit the amount of floatables and debris collecting in stormwater runoff and discharging off-site. In addition, on-site refuse management programs entail good housekeeping practices and help maintain a clean facility appearance.

Applicability

Commercial and industrial facilities can benefit from an active on-site refuse management program. Many facilities already employ such a program either formally or informally as part of good housekeeping efforts to maintain a clean, aesthetically pleasing business environment.

Litter reduction and recycling activities are essential to improving solid waste management. Nearly 65% of the City's landfill waste comes from local commercial and industrial businesses. Recycling programs can save landfill space, and because the City of Greensboro services recycling dumpsters free of charge, they can save business owners money.

Stormwater Utility Credit

To be eligible for stormwater utility credit for implementation of this BMP, organizations must develop and implement an on-site refuse management plan which focuses on litter reduction, recycling, and proper disposal and storage. Organizations wishing to receive credit for on-site refuse management, must prepare and submit an on-site refuse management plan. The plan should include the following items at a minimum:

1. A litter reduction program encouraging staff to properly dispose of waste materials. This program should outline the appropriate disposal options for all waste, including hazardous and non-hazardous and general solid waste material.
2. A comprehensive on-site waste material recycling program. This program should include all materials that could be reused or reclaimed either on-site or through the use of contractors of vendors. This may include paper wastes, waste treatment solids, and other materials.
3. Maintain area of refuse container covers designed to eliminate exposure to the environment (i.e. wind, rain, snow, etc.).

For more information regarding credit opportunities, refer to the City's *Stormwater Utility Credit Policy* document.

City of Greensboro Solid Waste Management

The City's Solid Waste Management Division offers twice-a-week garbage service as well as recycling service up to four times per week to its business customers. Business owners are responsible for providing city-approved trash and recycling dumpsters.

Businesses may recycle the following materials in the Recycle Greensboro program:

Office and computer paper	**Newspapers**	**Tin cans**	**Chipboard**
Plastic soda bottles	**Magazines**	**Empty aerosol cans**	
Plastic milk or water jugs	**Aluminum cans**	**Corrugated cardboard**	

The City does **NOT** allow the following to be disposed at the City landfill:

Aluminum cans	**Yard waste**	**Tires**
Lead batteries	**Large appliances**	
Anti-freeze	**Fluorescent bulbs**	

The Solid Waste Management Division publishes the *Business Waste Line* and *"One Man's Trash"* which includes articles such as profiles on recycling programs of local businesses, easy and effective things businesses can do to reduce waste, and updates on the City's collection services. *Business Waste Line* is published twice a year and *"One Man's Trash"* is published quarterly and sent to local businesses.

If you have any questions concerning the City's refuse and recycling program, or would like help setting up a recycling program for you business please contact the City of Greensboro Solid Waste Management Division at 335-5444.

3.2.3 Stormwater System Maintenance

Description

On-site stormwater system maintenance entails property owners or management regularly maintaining the stormwater system on their property. Often, it is very effective for individual facilities to periodically clean out on-site stormwater structures to assist in the City's effort in maintaining the stormwater system. By regularly maintaining on-site storm sewer systems and open channel conveyances, a facility may reduce the amount of sediment and other pollutants that can potentially migrate into the City's storm sewer system and downstream receiving waters. This helps the City meet the pollutant reduction goals associated with its federal National Pollutant Discharge Elimination System (NPDES) Stormwater Permit. Also, periodic cleanings of the stormwater infrastructure can prevent water back ups in the system and potential damage from flooding due to a clogged system.

Applicability

Sites that have stormwater conveyances (pipe system, open channel, and water bodies) on their property that drain the runoff from the site are responsible for maintaining the conveyances. Storm sewer conveyances that cross through private property but receive public runoff, will be maintained by the City of Greensboro. However, inlet structures that collect runoff from private property are the maintenance responsibility of the property owner, even if the structure is connected to a publicly maintained storm sewer pipe.

Stormwater Utility Credit

To be eligible for stormwater utility credit for implementation of this BMP, organizations must prepare and submit an on-site stormwater system maintenance plan. This plan must meet the following minimum criteria:

1. Catch basins (e.g. curb inlets, grate inlets, etc.) and outfalls must be cleaned a minimum of 2 times per year.
2. Curb and gutter systems must be cleaned a minimum of 4 times per year.
3. Other implemented structural BMPs must be routinely maintained and inspected on an annual basis (minimum).

For more information regarding credit opportunities, refer to the City's *Stormwater Utility Credit Policy* document.

City of Greensboro "SWIMS" Program

The City Storm Water Services Division is currently in the process of inventorying the storm sewer infrastructure and open channel conveyance systems in the city limits. The inventory includes public and private storm sewer systems (pipe diameter size is 12 inches or greater), open channels, and ponds and lakes.

Attribute information, such as structure depth, structure condition, etc, along with location information is gathered for each structure in the system (e.g. pipe, curb inlet). The City will use this information along with a Geographical Information System (GIS) to develop a proactive program termed the Stormwater Infrastructure Management System ("SWIMS"). This program will optimize maintenance of public storm sewer systems by specifying which structures need immediate repairs or cleaning before further problems occur. The program will also allow the City to predict which structures need to be cleaned more frequently based on data collected in the field and the associated land uses.

3.2.4 Paved Area Sweeping

Description

A paved area sweeping program can significantly reduce sediment and other potential pollutants from migrating into the City's waterways. Paved areas are a source of various pollutants (especially hydrocarbons and heavy metals emitted by vehicles). Small pollutants attach to sediment; and when it rains, the sediment, along with the attached pollutants, flow with the stormwater runoff to the nearest waterway. By employing a regular paved area sweeping program, a facility can dramatically reduce the amount of sediment entering the stormwater runoff. This not only helps the City maintain clean waterways but also improves general housekeeping efforts at individual facilities.

Applicability

Essentially, every commercial and industrial facility that has paved areas can employ a sweeping program. Commercial and industrial facilities with large parking lots often receive the most benefit from paved area sweeping. In addition, it is often more cost effective to sweep large paved areas as compared to small paved areas. Many industries may already be employing routine paved area sweeping to comply with their NPDES Storm Water Permit.

Stormwater Utility Credit

To be eligible for stormwater utility credit for implementation of this BMP, organizations must develop, submit, and document implementation of a detailed paved area sweeping management plan. The plan should include at a minimum: sweeping frequency, name of sweeping contractor, sediment and debris disposal method, and areas regularly swept. All paved areas must be swept a minimum of once every two weeks. For more information regarding credit opportunities, refer to the City's *Stormwater Utility Credit Policy* document.

City of Greensboro Paved Area Cleaning Program

The City of Greensboro Street Cleaning Division is responsible for periodically cleaning major and secondary public roads and public parking lots. The City uses a street sweeper that is equipped with a vacuum to pick up loose debris once it is swept to the curb. This prevents the debris from entering the storm sewer system.

3.2.5 Used Oil Recycling

Description

Petroleum-based products are one of the major pollutants found in many urban surface waters. One of the major contributors is improperly managed used oil. Therefore, a used oil recycling program employed at facilities that utilize oil in their operations can be extremely beneficial with respect to improving stormwater runoff quality. Many facilities that utilize oil should already have a used oil recycling practice in place as it has become relatively convenient and cost effective.

Applicability

Commercial and industrial facilities that use oil in its operations can employ a used oil recycling program. There are many commercial vendors that collect used oil and haul it to a commercial recycling facility. This significantly reduces the amount of effort required by facilities to employ used oil recycling. Furthermore, by using a reputable used oil recycling company, a facility can reduce its potential liability regarding used oil contamination.

Stormwater Utility Credit

To be eligible for stormwater utility credit for implementation of this BMP, organizations must meet the following minimum criteria:

1. Offer and maintain an on-site, used oil recycling collection area.
2. Utilize a registered commercial oil recycling company to collect, haul, and recycle the used oil, as necessary.
3. Provide annually to Storm Water Services copies of all manifests for used oil collection performed each year.
4. Display City of Greensboro Used Motor Oil Recycling informational material in clearly visible and frequented on-site locations.

For more information regarding credit opportunities, refer to the City's *Stormwater Utility Credit Policy* document.

City of Greensboro Household Hazardous Collection Center

Russell and Meiorin conducted a study (1985) of household practices and found that 11 percent of homeowners who change their motor oil disposed of it directly to street drains and another 14 percent disposed of it on the ground (Horsely and Witten).

The City of Greensboro, Guilford County, and ECOFLO, Inc. provide a service to collect household hazardous waste from all households in Guilford County (no commercial or business

waste is accepted). The Household Hazardous Waste Collection Center is located at 2750 Patterson Street, Greensboro.

3.2.6 Covering

Covering includes protecting certain areas of a facility from contact with precipitation. Covering dramatically reduces the contact of precipitation on potential stormwater pollutant sources, thereby reducing the pollutant levels in stormwater runoff from a particular property. Covering can include a building, canopy, or other structure that directs rainfall away from areas of concern. Areas at a facility that are commonly covered in some form are stockpile areas, hazardous material storage areas, maintenance areas (i.e. motor vehicle), and loading/unloading areas.

Applicability

Covering is a common practice employed by many commercial and industrial facilities. The City recognizes that constructing coverings for large outdoor storage areas may not be cost effective for some facilities and other BMPs may be utilized.

Storm Water Utility Credit

To be eligible for stormwater utility credit for implementation of this BMP, covering must be employed at all hazardous and petroleum-based material storage areas and any area that entails maintenance activities. Organizations must meet the following minimum criteria:

1. All hazardous and petroleum-based materials must be covered and protected from stormwater contact.
2. A spill control and response plan must be developed and submitted to Storm Water Services for all hazardous and petroleum-based materials stored on-site.
3. All maintenance activities must be performed under covered areas.
4. A site sketch with the covered areas must be submitted to the Storm Water Services Division with the credit application before final approval of a covered area can be granted.

3.2.7 Spill Containment

Description

Spill containment BMPs are provisions incorporated to prevent spilled materials which are potentially hazardous from migrating outside storage areas. The containment may be a dike or pit (for example, a concrete or steel berm) constructed around individual storage containers or a storage area. The dike or pit will may have drain pipes with valves to allow “clean” stormwater to discharge from the containment area; however, the valve is kept shut under normal conditions in cases of a leak or spill.

If the area to be contained is a large area with a storm drainage network, it may be appropriate to construct a basin at the storm sewer outfall. The basin can be designed to trap floating materials through the use of a skimmer baffle, as shown in Figure 3.1.

It is preferred, if possible, that storage areas of significant materials be covered to prevent rainfall from entering the containment area.

Applicability

If a facility uses hazardous or petroleum-based materials (i.e. chemicals, wastes, oils, etc.) and stores them outside, they should employ spill containment around their storage areas. In many cases, however, if facilities do store hazardous materials outside, federal law *(40 CFR Part 112 - Oil Pollution Prevention Regulations* and *40 CFR Part 264 - Hazardous Waste Regulations)* require such facilities to have spill containment for these areas.

Stormwater Utility Credit

To be eligible for stormwater utility credit for implementation of this BMP, all hazardous and petroleum-based materials that are stored outside must have spill containment. Organizations wishing to receive credit for spill containment must meet the following minimum criteria:

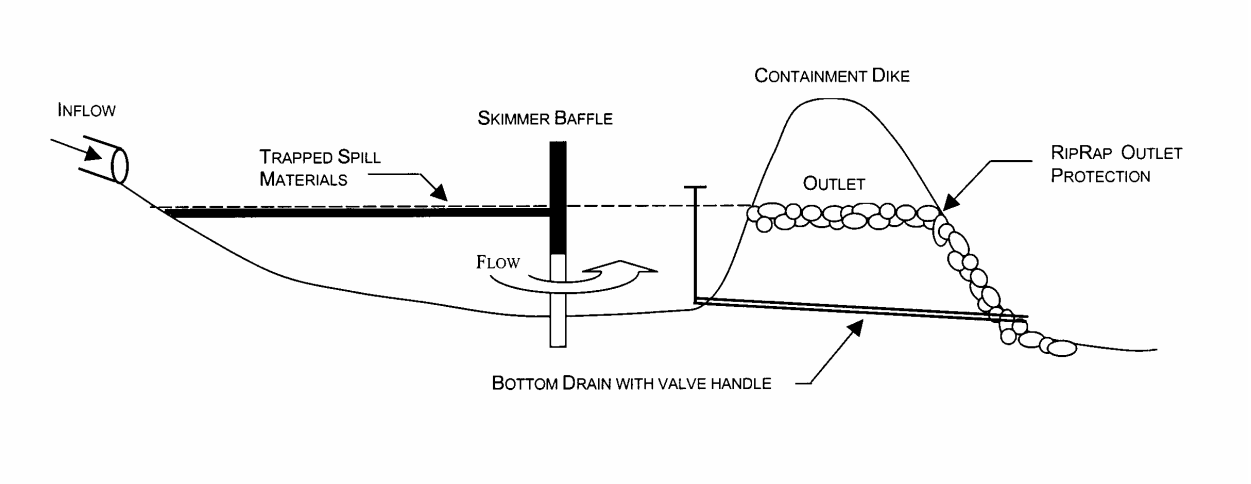
1. All spill containment facilities must be capable of containing 110 percent of the volume of the largest container in the applicable storage area. For example, if the largest container in a storage area is a 55-gallon drum, the spill containment storage area must have at least 61 gallons (55 x 110%) of volume.
2. For storage areas that contain potentially hazardous materials that dissolve in water or otherwise do not float, a spill containment structure must be provided with a valve. The valve must remain closed during normal facility operation. In the event of a rainfall event, the collected stormwater must be visually inspected (sight and smell) for any potential contamination. If no potential contamination is visible, the containment valve may be opened and the collected stormwater discharged. Any contaminated stormwater must be disposed in a proper manner.
3. For storage areas that contain potentially hazardous material that floats on water (e.g. oil), a structure using a skimmer baffle as shown in Figure 3.1 or other trapping provision may be used.
4. A site plan detailing the storage areas and spill containment must be submitted to Storm Water Services.
5. Display easily visible signage indicating a hazardous material storage area.
6. Implement a regular inspection program (once per week minimum) for all spill containment areas.
7. Document all inspection and maintenance activities associated with spill containment facilities (Inspection and maintenance log should be available for City review at any time).

For more information regarding credit opportunities, refer to the City's *Stormwater Utility Credit Policy* document.

Spill Containment for City of Greensboro Hugh Medford Service Center

The City of Greensboro has constructed a spill containment structure to protect potential spill areas at its Service Center. The structure is a wet basin with a skimmer baffle that traps floating material at the surface (as shown in Figure 3.1). For more information, contact the Storm Water Services Division.

Figure 3.1: Example Spill Containment Structure for Floatable Material



3.2.8 Erosion and Sedimentation Control

Description

Soil erosion has a major impact on the quality of surface waters. Erosion increases the sediment loading to surface waters causing adverse impacts such as increased turbidity, reduced light penetration, clogging of gills/filters of fish and aquatic invertebrates, and reduced spawning. Other impacts of increased sediment loading occur in low flow receiving waters, such as slow moving meandering streams, ponds and lakes, where the sediment has a chance to settle out. Impacts include smothering of aquatic habitat, more rapid filling of impoundments, increasing the need for costly cleanouts and decreasing the aesthetic value (Schueler, 1987).

The greatest amount of soil erosion occurs during development construction and related land disturbance, where grading activities expose the soil. Soil erosion can also occur on developed sites where pervious areas are not well stabilized (for example, sparse grass cover), and in urban streams where increased flow velocities due to increased runoff has eroded the stream banks, and

other places where runoff has been concentrated and the conveyance system is not adequately protected to resist erosion.

Applicability

For all land disturbance activities erosion and sedimentation controls are to be implemented to prevent excessive sediment transport via stormwater runoff. After construction, it is important that property owners periodically inspect the facility grounds to check for any erosion problems or areas where earth is exposed due to poor grass cover or landscape cover.

City of Greensboro Soil Erosion and Sedimentation Control

Through the Soil Erosion and Sedimentation Control Act of 1973 and the City's National Pollution Discharge Elimination System (NPDES) Stormwater Permit, the City of Greensboro enforces sedimentation and erosion controls on all new commercial and residential projects. For sites where land disturbances are greater than one (1) acre, a grading permit is required by City Ordinance. For sites where land disturbances are less than one (1) acre, no grading permit is required; however, the City will still manage and enforce erosion control on the site.

Refer to the City's Soil and Sedimentation Control Section Standards of Practice for more information on the City's regulations, policies, and procedures. Or, contact the Field Services Section of the Storm Water Services Division at 373-2812.

3.3 Non-Structural BMPs

3.3.1 Open Vegetated Conveyance

Description

Open vegetated conveyances may be used instead of curb and gutter (where permitted) and hard piping to convey stormwater runoff where feasible. Open vegetative conveyances may be channels, swales, and, where runoff is in the form of sheet flow, any vegetated area that accepts runoff. Vegetated conveyances help to improve water quality by providing partial pollutant removal as the water is filtered by the vegetation and an opportunity for a portion of the water to infiltrate into the soil. They can also improve stormwater runoff quantity management by reducing the velocity of the flow through the conveyance and providing some infiltration into the soil.

Applicability

Vegetated conveyance systems can best be incorporated into moderate to low density development where land area is available and where the land surface is gently sloping (5% maximum). The site soils must be able to withstand erosion and a dense cover of strong rooted